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Comparative review of surgical techniques for the repair of tympanic membrane perforation: Systematic review

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ABSTRACT

Background: Tympanic membrane perforation can be repaired surgically by various methods of tympanoplasty, restoring middle ear function and hearing. The purpose of this review was to contrast various surgical techniques used to treat tympanic membrane perforations. *Method:* From 2018 to 2022, the PubMed, Embase, and Cochrane Library databases were screened as part of a systematic search. The authors independently found the studies that met the requirements for selection. Every contributor evaluated the whole text of the selected articles. Outcomes and study features were documented. *Results:* Three treatment groups had CT, two had FGM, five had TFT, and seven had BCT. There was variation in the closure rates in the TFT groups (mean 83.2%), BCT groups (mean 91.2), CT groups (mean 88.3), and FGM groups (mean 87%). In the TFT, the closure rates ranged from 83% to 96% (mean 83.2%). The closure rate statistics indicate that BCT has higher closure rates than TFT, CT, and FGM. The BCT and other surgical procedures did not significantly differ from one another for hearing improvement, showing that the hearing benefits from these treatments were equivalent. The six papers in total indicated improvements in hearing. *Conclusion:* When correcting tiny to medium-sized TM perforations, butterfly cartilage tympanoplasty works satisfactorily. In addition, this approach is highly tolerated and results in a shorter recovery period and postoperative pain.

Keywords: Surgical techniques, tympanic membrane perforation, surgical repair

1. INTRODUCTION

When tympanic membrane perforations are treated with tympanoplasty, acceptable healing and hearing results are often obtained (Shen et al., 2013). Endoscopic transcanal techniques or open postauricular, transcanal, or endaural

methods can be used for tympanoplasty procedures. On the other hand, only a restricted group of patients under the guidance of skilled practitioners can employ the transcanal method; postauricular and endaural procedures have the potential to leave surgical scars (Hardman et al., 2015; Pap et al., 2019). Tympanoplasty can be done under local anaesthesia, but because of the dangers and problems involved, it is usually done under general anaesthesia in operating rooms (Shen et al., 2013; Huang et al., 2020). With these things in mind, investigating other options is crucial to raising the effectiveness of TM repair (Shen et al., 2013).

Butterfly cartilage tympanoplasty has been a widely used method for the treatment of TM perforation (Kim et al., 2019; Gülşen and Erden, 2020; Van-Stekelenburg and Aarts, 2019; Bartel et al., 2019). The cartilage graft that is formed like butterfly wings before being inserted into the TM to seal the perforations—much like an ear tube—is what gave rise to the term "butterfly" (Eavey, 1998). Despite being easy to use, practical, and successful, BCT's effectiveness has not been well studied in the literature, despite its simplicity. The majority of studies had small sample numbers, and the outcomes following surgery have been inconsistent. As far as we are aware, few studies assessed the efficacy of tympanoplasty, particularly in the case of chronic perforations. Therefore, the purpose of this thorough review is to evaluate how well different types of tympanoplasty work.

2. METHOD

The Preferred Reporting Items for Systematic Reviews and Meta-analysis standards were followed during the analysis (Moher et al., 2015).

Method of Search and Study Choice

From 2018 to 2022, the PubMed, Embase, and Cochrane Library databases were screened as part of a methodical search. Once duplicates were eliminated, each analysis step was carried out separately by the authors. MeSH terms and text words such as butterfly cartilage, inlay cartilage, tympanoplasty, myringoplasty, tympanic membrane, tympanic, eardrum, tympanic membrane perforation, membrane perforation, tympanic, eardrum perforation, perforation, eardrum, rupture, tympanic membrane were used to identify publications.

Inclusion and exclusion criteria

Patients with TM perforations, patients who had surgery in the experimental groups, outcomes with comprehensive data that could be analysed, and observational (prospective or retrospective) studies or randomised control trials were the eligibility requirements. The following were the criteria for exclusion: The use of in vitro research, case reports, reviews, letters, and xenogeneic and allogeneic experiments without control groups; qualitative studies without specific data.

Review and analysis

A summary of the data from the included studies was taken and is shown in (Table 1). Data on the rate of closure, improvements in hearing, length of surgery, postoperative pain response, complications, and expenses were gathered.

3. RESULTS

Seven studies in all met the inclusion criteria and were selected. Three retrospective studies and four prospective studies the qualifying studies, which had a minimum follow-up length of 90 days, were published between 2018 and 2022. Seven treatment groups had BCT, five had TFT, three had CT, and two had FGM. Instead of using data for only the research participants who finished, these studies used data with the final outcome carried forward. Table 1 provides comprehensive details on the included research, such as the reference, years, demographics, and results. The closure rates in the TFT varied from 83% to 96% (mean 83.2%), in the BCT groups from 80% to 97% (mean 91.2), in the CT groups from 85% to 92% (mean 88.3), and in the FGM groups from 83% to 91% (mean 87%) (Table 2).

The closure rate results show that BCT outperforms TFT, CT, and FGM in terms of closure rates. Six articles in total—reported improvements in hearing. The studies that were considered indicate that there was a substantial difference between preoperative and postoperative ABGs, and that the auditory outcomes improved. The BCT and other surgical techniques did not significantly differ from one another, indicating that the hearing gains from these techniques were comparable. Two investigations examined how long the

operations took to complete, comparing the times of BCT and CT as well as BCT and CT. The BCT groups had an average operation time of 31.8 minutes, the CT groups of 51 minutes.

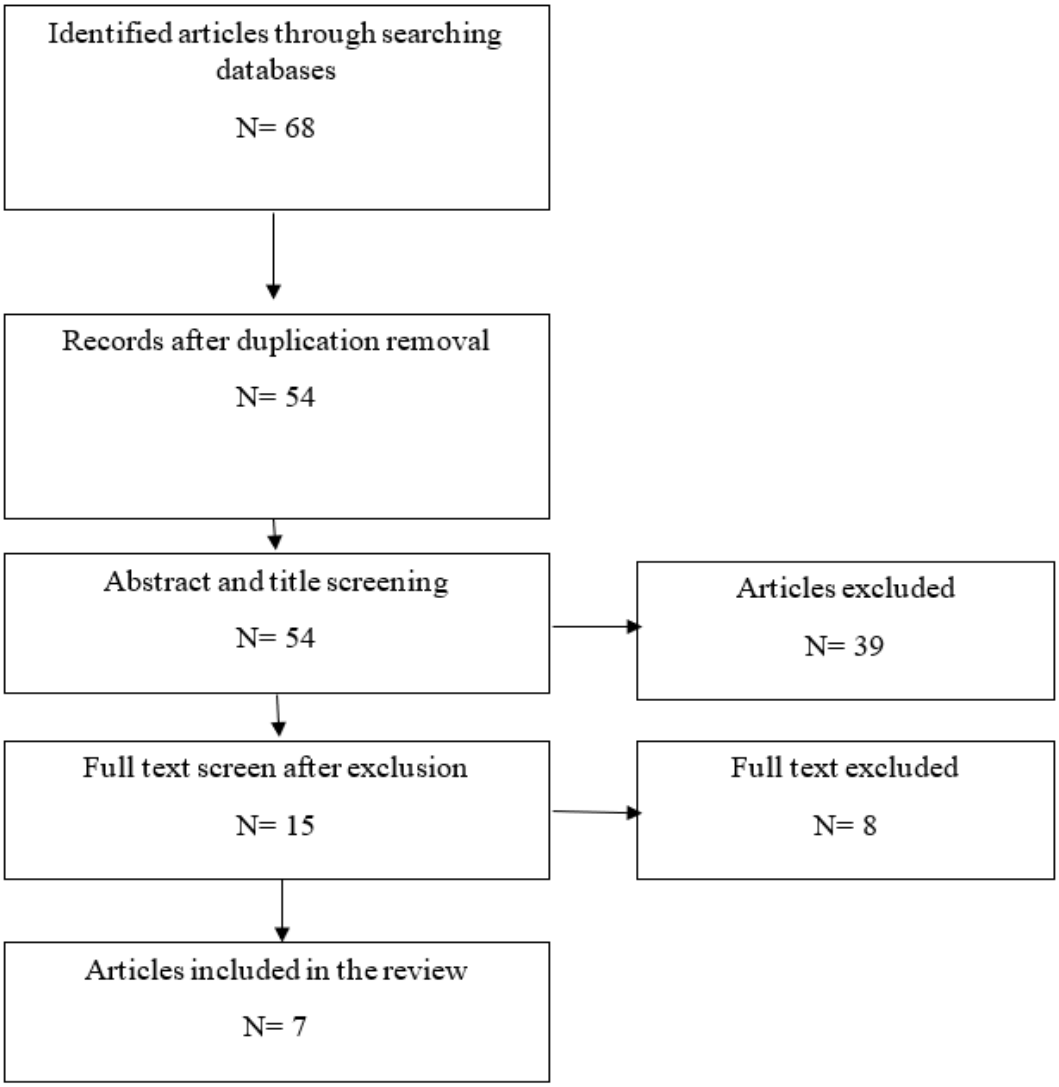

Figure 1 Consort chart of selection process

Table 1 Characteristics of included studies

Citations	Aim	Results	conclusion	included participants
Gülşen and Erden, 2020	To assess the functional and surgical outcomes of endoscopic push-through myringoplasty and endoscopic butterfly-inlay	Endoscopic push-through myringoplasty and endoscopic butterfly-inlay cartilage myringoplasty had graft success rates of 94% and 91%, respectively.	The endoscopic butterfly-inlay cartilage myringoplasty technique is easier to do technically, needs less packing, and takes less time	71 patients had tympanic membrane anterior holes that ranged in size from minor to medium.

	cartilage myringoplasty for the treatment of anterior tympanic membrane perforation.		to finish during surgery.	
Kim et al., 2019	To evaluate inlay BCT's effectiveness and contrast it with underlay traditional cartilage tympanoplasty in terms of hearing results and success rate.	In 8.7% of the inlay group's instances and 23% of the underlay group's, there was re-perforation. Underlay group patients experienced extensive tympanic membrane granulation, whereas one inlay group patient experienced a major infection.	Success rates of inlay BCT are similar to those of underlay standard cartilage tympanoplasty.	Thirty-five patients who had inlay BCT were included in the study.
Van-Stekelenburg and Aarts, 2019	To ascertain the parameters that influence the closure of the tympanic membrane and the impact they have on the overall risks of closure and the improvement of hearing after myringoplasties.	The myringoplasty graft's overall success rate was 75%. Higher success rates of 85.4% and 85.5% were obtained if cartilage and butterfly graft were utilised, as opposed to temporalis fascia (61.3%). The surgeon's expertise determined the operation's success rate. If a skilled surgeon employs cartilage, the chances of success are 91.9%; if a less skilled surgeon utilises fascia, the chances of success are 66.7%. The use of silastic sheets or the occurrence of a postoperative problem could potentially compromise the outcome of the procedure. If the perforation was closed, the mean ABG improved by 10.10 dB, as opposed to 3.38 dB following a failed surgery.	The surgeon's skill level and the kind of graft utilised determine the myringoplasty's success rate.	195 patients who had myringoplasty procedures were examined.
Bartel et al., 2019	To demonstrate the surgical outcomes of a type 1 endoscopic tympanoplasty performed on a paediatric patient using a cartilage butterfly graft or fascia temporalis.	In all, 54 tympanic membrane operations were done on; 25 of them had cartilage butterfly graft while the other 29 used an underlay fascia temporalis. In 92.6% of instances, closed and dry tympanic membranes were achieved six months after surgery.	Every chronic otitis media paediatric without cholesteatoma can have transcanal type 1 endoscopic tympanoplasty, which is effective surgery.	Individuals have an intact ossicular chain and a diagnosis of chronic otitis media without cholesteatoma.
Dave and Sharma, 2019	To assess the epithelialization of the graft and the	Group 2 had 83.34% and Group 1 had 85.7% graft epithelialization. There was no discernible statistical	In revision tympanoplasty, the outcomes of	Thirty-three revision instances with dry central

	hearing result in revision tympanoplasty type 1 with fascia lata and cartilage as the graft material.	difference in the two groups' success rates. Additionally, there was no discernible change in the hearing's conclusion. Both groups had a notable improvement in their overall hearing. The mean postoperative ABG of 20 db or less was observed in 63.6% of the operated patients.	fascia lata and cartilage as grafts are similar concerning epithelialization of graft and hearing.	perforations were split into two groups
Ulku, 2018	To assess and contrast the outcomes of temporalis fascia tympanoplasty with inlay BCT.	The tympanic membrane's anatomic integrity rates were 88% for over-underlay fascia tympanoplasty, 91% for underlay perichondrium cartilage island tympanoplasty, and 92% for inlay BCT.	The results of temporalis fascia tympanoplasties and inlay BCT are comparable in terms of anatomy and function.	78 patients undergoing primary type 1 tympanoplasty, 17 patients, over-underlay temporalis fascia, 36 over-underlay perichondrium-cartilage island, and 25 inlay butterfly cartilage.
Mourya et al., 2018	To assess and contrast the effectiveness and practicality of different office operations, such as fat plug myringoplasty, chemical cauterization, and BCT.	The results showed that the success rates for chemical cauterization, fat plug, and BCT were 91.1, 94.5, and 97%, respectively.	Depending on the patient's health and convenience, chemical cauterization, fat plugs, and BCT were suggested as alternatives to tympanoplasty in small to medium-sized central tympanic membrane perforations.	The study included 300 patients

Table 2 Type of operation and closure rate

Citation	Study design	Operation type	BCT closure rate	CT closure rate	TFT closure rate	FGM closure rate
Gülşen and Erden, 2020	Prospective	BCT & CT	85	85	61	-
Kim et al., 2019	Retrospective	BCT& CT	97		88	-
Van-Stekelenburg and Aarts, 2019	Retrospective	BCT, CT & TFT	80	88	83	-
Bartel et al., 2019	Prospective	BCT & TFT	92	92	88	-
Dave and Sharma, 2019	Prospective	BCT, CT & TFT	97	-	-	91

Ulku, 2018	Retrospective	BCT, CT & TFT	95	-	96	-
Mourya et al., 2018	Prospective	BCT & FGM	93	-	-	83

4. DISCUSSION

Tympanoplasty surgical technique and graft selection are typically influenced by patient, disease, surgeon, and institutional (Yao et al., 2021; Huang et al., 2021). For primary tympanoplasty, the underlay technique with a temporal fascia graft is currently the favoured approach (Pap et al., 2019). The tympanomeatal flap must be elevated in order to perform the underlay method, which has a risk of harming the chorda tympani, ossicles, and tympanic annulus (Hod et al., 2013). Although earlobe fat graft myringoplasty is a minimally invasive procedure usually carried out under local anaesthesia, it is less successful anatomically and functionally in big holes (Lee and Kim, 2018). BCT is another minimally invasive procedure that has been shown to successfully repair TM perforations up to 100% of the time (Eavey, 1998).

Results related to healing and hearing are crucial benchmarks for assessing how well a surgical strategy worked (Eavey, 1998). BCT and traditional tympanoplasty with a temporal fascia or cartilage graft produce comparable closure rates in terms of primary outcomes and graft uptake, however, its performance is better than that of FGM, with an odd ratio of 3. These results, which show that BCT yields adequate graft absorption rates for TM repair, were also confirmed by earlier research (Ulku, 2018; Mourya et al., 2018; Dave and Sharma, 2019). Additionally, patients with residual or re-perforation, persistent mucosal dysfunction, retraction pockets, and Eustachian tube dysfunction were more likely to benefit from cartilage transplants (Yung, 2008). While the thickness and stiffness of the cartilage may potentially affect the auditory gains, short-term follow-up findings indicate that the ABG closure of cartilage and fascia grafts is identical (Kalcioglu et al., 2019).

In big holes, cartilage grafts appear to provide even greater long-term postoperative hearing improvements than temporal fascia (Kalcioglu et al., 2019). The patients participating in our research did not have any serious middle ear problems; instead, they had simple chronic TM perforations, and short-term follow-ups were mostly used to measure hearing improvements. In a similar vein, postoperative pain and discomfort were lower in BCT patients. The minimal incision without ear packing, canalplasty, or tympanomeatal flap elevation can significantly reduce postoperative discomfort. However, there is limited evidence to determine which approach has the lowest incidence of postoperative complications (Huang et al., 2021). We found a study reported 6 cases of postoperative infection in the BCT group and 15 cases in the TFT Mauri et al., (2001), suggesting lower postoperative morbidity with BCT.

Similar reperforation rates was reported between the BCT and TFT groups, despite the BCT observing 5 cases of retraction pockets (Couloigner et al., 2005). Comparable or no incidence of post-operative problems was also shown by other investigations (Ulku, 2018; Dave and Sharma, 2019). The cartilage transplant depends on the connected perichondrium for nourishment because it lacks vascularization (Mauri et al., 2001). A cartilage transplant that contains perichondrium on one or both sides is more viable in dry ears than one that is completely naked, and may considerably lower the risk of infections and reperforation (Smyth and Kerr, 1970). Additionally, it was recommended that in situations of contralateral tympanic retraction or otitis media with effusion, closure should be achieved using an underlay cartilage transplant (Couloigner et al., 2005). As such, it is important to investigate ways to maximise results while reducing risks.

5. CONCLUSION

The efficiency of butterfly cartilage tympanoplasty in treating small to medium-sized TM holes is satisfactory. Additionally, there is less recovery time, postoperative discomfort, and this technique is well tolerated. Nevertheless, further research is need to determine how well massive perforation repairs work.

Ethical approval

Not applicable.

Informed consent

Not applicable.

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Conflict of interest
The authors declare that there is no conflict of interests.

Data and materials availability
All data sets collected during this study are available upon reasonable request from the corresponding author.

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